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EQUIPMENT FOR MEASURING PRESSURES IN THE APERTURES BETWEEN THE VANES OF COMPRESSOR IMPELLER WHEELS

V. A. Zhebko, Yu. G. Otsechkin, and
G. V. Pavlenko

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EQUIPMENT FOR MEASURING PRESSURES IN THE APERTURES BETWEEN THE VANES OF COMPRESSOR IMPELLER WHEELS

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During the process of finishing the stages of an axial-flow compressor, it usually becomes necessary to study in detail the flow structure in the working grid. Various experimental models are used in solving the problem. The simplest method from the point of view of experimental technique is flow simulation on immobile flat or circular grids. This method, despite its high labor consumption, does not permit a number of factors to be taken into account which considerably affect the flow around the working grid, for example, the effect of centrifugal forces, the transient nature of incident flow, etc. The method in which the flow passes behind the working grid in relative motion, with the pneumatic probe located on a special rotary attachment with sequential step reaming of the cross section of the working channel between the blades, is better [1, 2, 3]. This method provides more reliable results. However, it has a number of disadvantages: the complexity of the attachment which provides step selection of pressures in relative motion and transmission of these measurements to fixed manometers through special sealed chambers, the high labor consumption of the experiment (similar to investigations of plane grids), and the impossibility of studying flow transfer processes in the grid. /50*

*Numbers in the margin indicate pagination in the original foreign text.

The equipment developed at the Laboratory of Turbomachines of the Khar'kov Aviation Institute is devoid of these disadvantages to a considerable degree. The equipment is intended for /53 studying the flow structure in the working grid during stationary and transitional operating modes of the latter.

A block diagram of the equipment is shown in Figure 1. The arrangement of the equipment components in the flow-through section of the experimental stage is presented in Figure 2. The

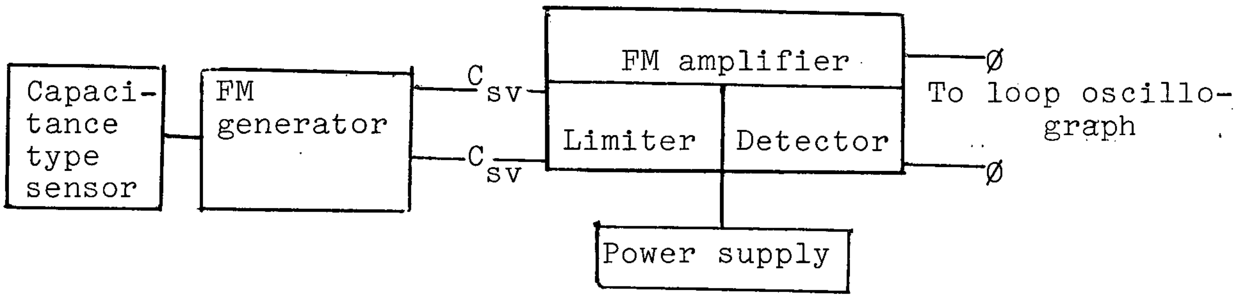

Figure 1. Block diagram of the device

connected channel (position 2), a capacitance-type sensor (position 3) and a frequency modulation generator (position 4) are located on a special rotary attachment, mounted on the impeller (position 1) and rotated by a DC rpm-regulated electric motor (position 5). The working signal is transmitted from the circuits located on the rotary attachment to the immobile attachment with the aid of capacitance-type contactless junctions (position 6).

The FM generator (Figure 3) operates on a frequency on the order of 12 MHz and its circuit includes a capacitance-type pressure sensor. The capacitance of the sensor, which varies the generation frequency, changes as pressure varies in the channel between the blades. The FM voltage enters the input of the FM amplifier through the coupling capacitor (Figure 4). Spurious amplitude modulation is suppressed by a limiter. The limited and amplified signal is detected and amplified and enters a loop oscillograph. Signals from the sensor of impeller rotation and the rotation portion of the attachment are fed to the oscillograph simultaneously. An oscillogram measuring total pressure $\tilde{P}_{02}$ in the apertures

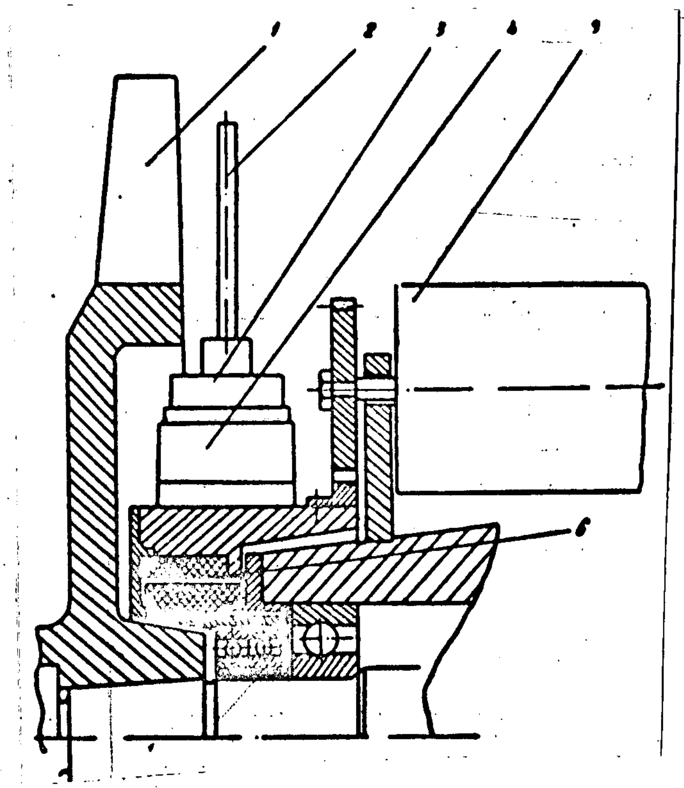

Figure 2. Attachment for measurement in relative motion

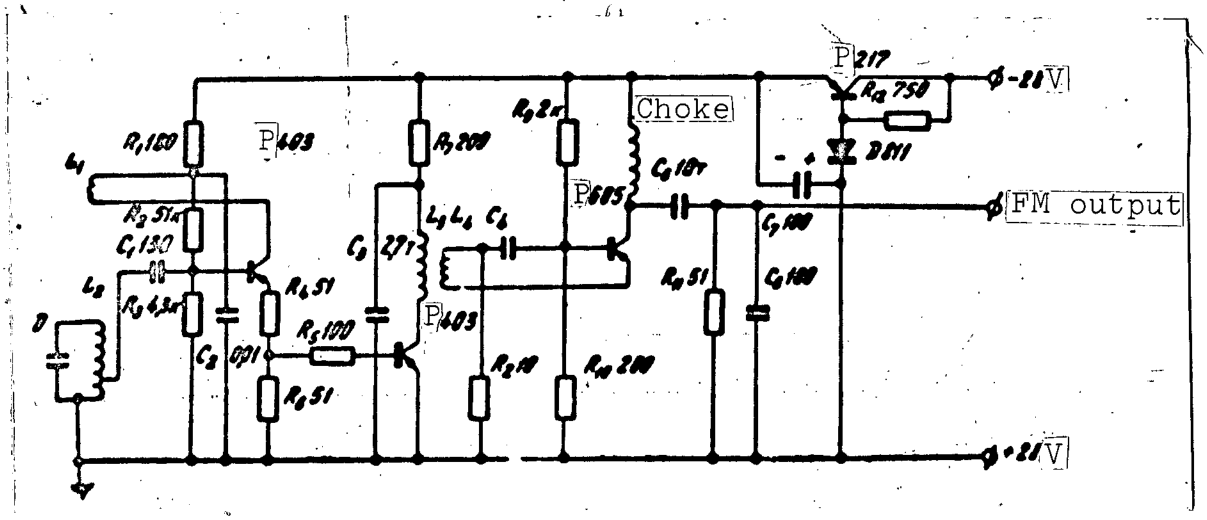

Figure 3. FM generator

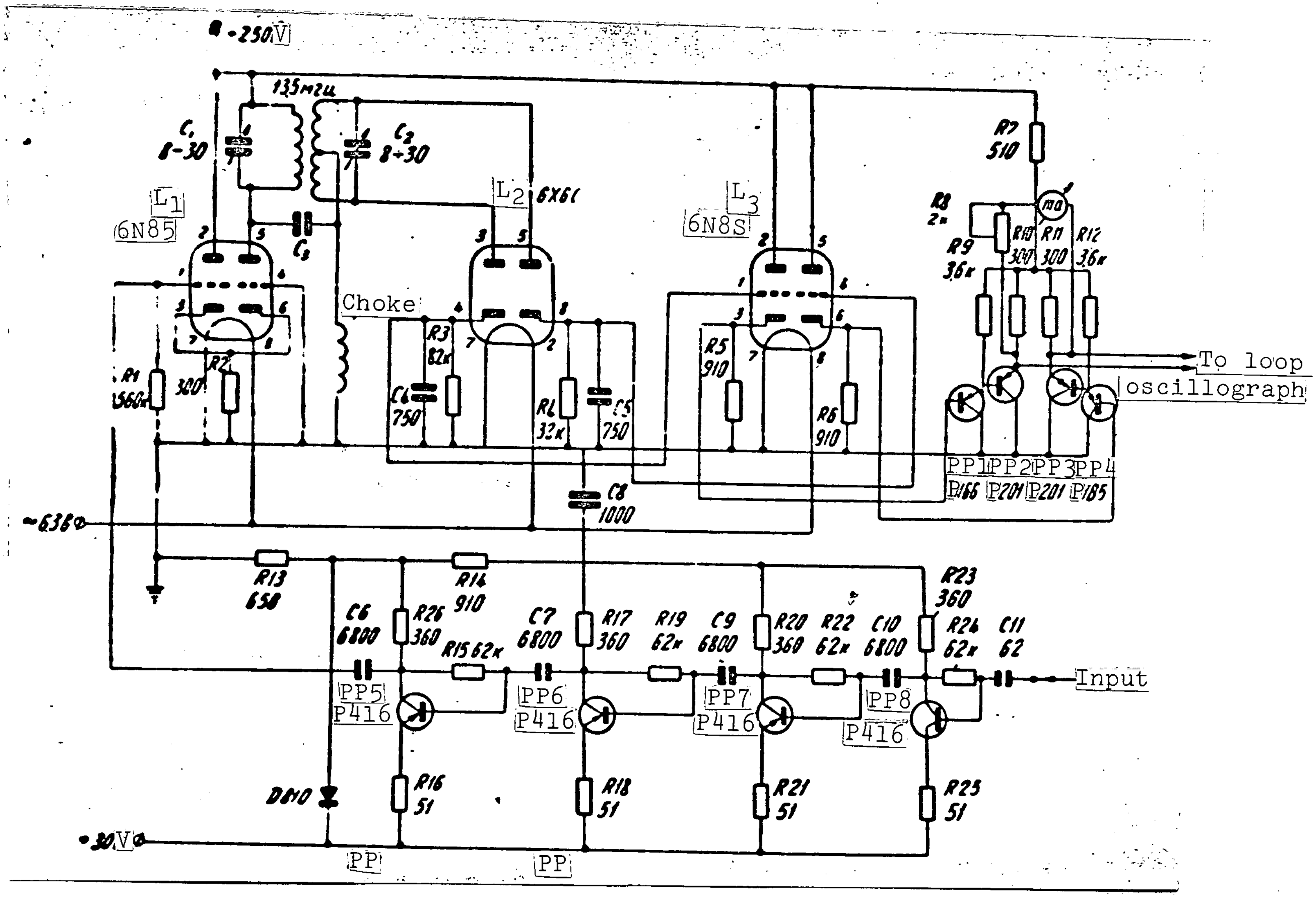

Figure 4. FM amplifier

between the blades of the compressor impeller channels, the revolutions of the impeller n_{imp}, the revolutions of the attachment n_{att} and the time marker from the audio generator (AG), obtained with the aid of the given apparatus, are presented in Figure 5 as an example.

The frequency of the signals from the blades, fed from the rotary capacitance-type sensor, depends on the rotating frequency of the impeller, and that of the attachment depends on the number of impeller blades and is calculated by the formula

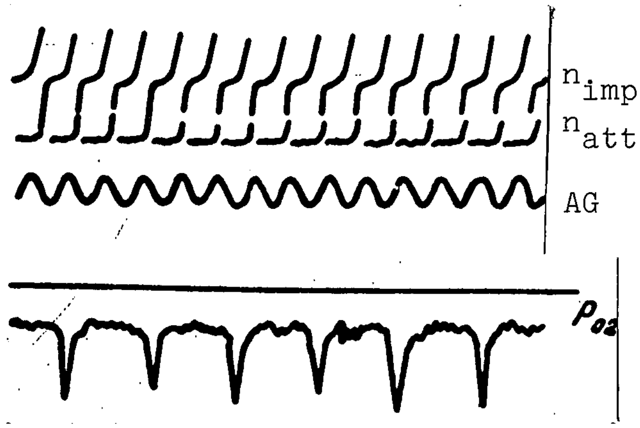

Figure 5. Oscillogram of measurement of total pressure $\tilde{P}_{02}$ in relative motion

$$f_s = (f_{imp} - f_{att})z \text{ [Hz]}$$

where f_{imp} — the rotational frequency of the impeller;

f_{att} — the rotational frequency of the attachment;

z — number of impeller blades.

It is obvious from the formula that slight deviations in revolutions of the attachment or impeller have a very strong effect on signal frequency f_s, and therefore, a more desirable drive arrangement would be one from an impeller shaft with constant asynchronous coupling.

The bandpass of the apparatus when using a large sensor is determined by the bandpass of the connected channel. The natural frequency of the connected channel is calculated by the formula

$$f_{c.c} = \frac{60,000}{l_{c.c}} \text{ [Hz]}$$

where $l_{c.c}$ — length of the connected channel in mm.

In our case, $l_{c.c}$ = 60 mm and $f_{c.c}$ = 1000 Hz. The working /54
frequency is within the range from 0 to 300 Hz.

REFERENCES

1. Ushakov, K. A. and I. V. Brusilovskiy. Investigating the Circular Grids of the Rotary Impeller of an Axial-Flow Fan. Promyshlennaya aerodinamika, Issue 10, Oborongiz, 1958.

2. Kolesnikov, A. V. Experimental Investigation of the Flow Structure Behind the Impeller of an Axial-Flow Fan in Relative Motion. Promyshlennaya aerodinamika, Issue 12, Oborongiz, 1959.

3. Dovzhik, S. A. and A. S. Ginevskiy. Pressure Losses in the Blade Rims of an Axial-Flow Subsonic Compressor. Promyshlennaya aerodinamika, Issue 20, Oborongiz, 1961.

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